FIG. 1

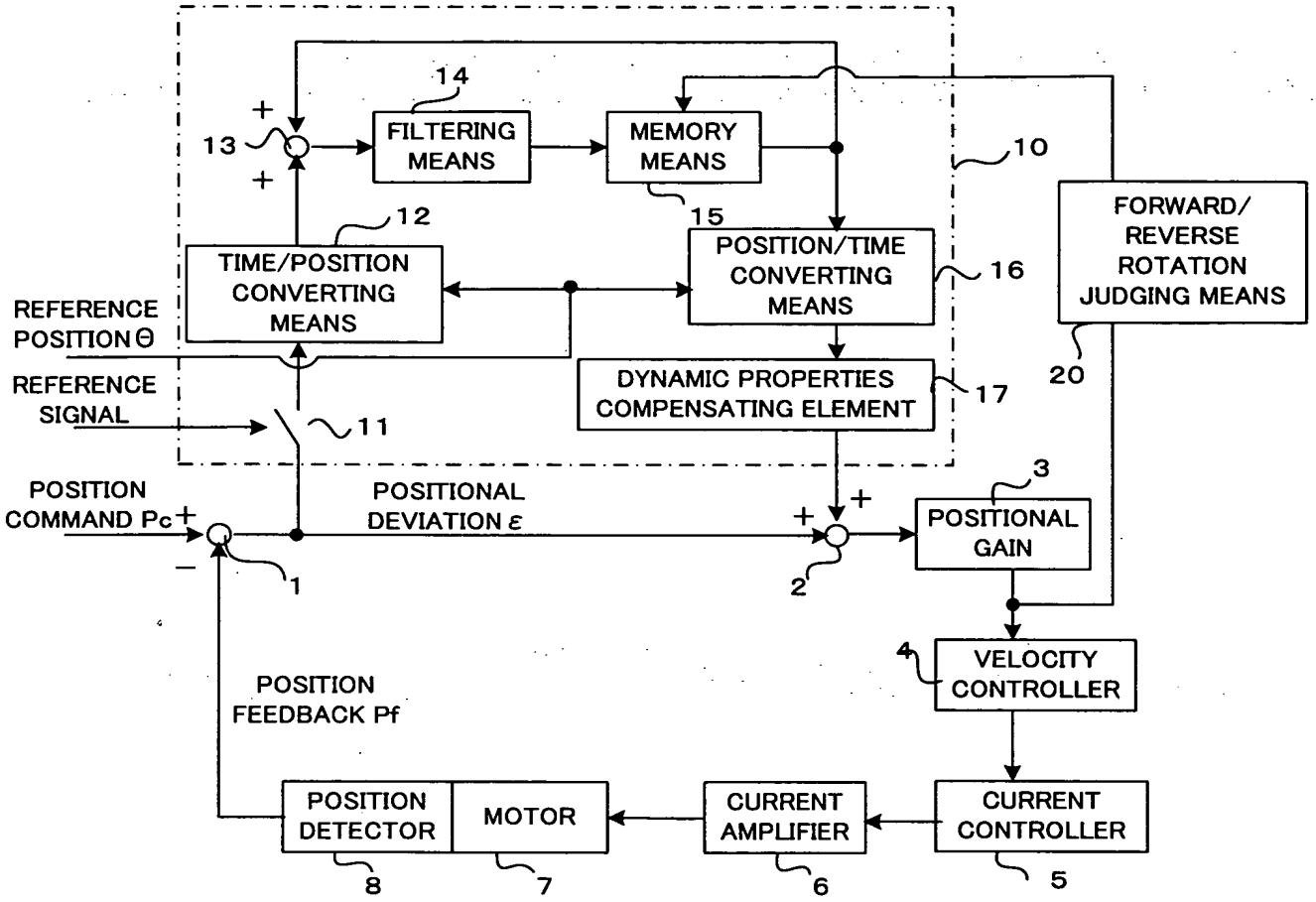

14
FILTERING MEANS
MEMORY MEANS
10
13
+
+
15
12
TIME/POSITION CONVERTING MEANS
POSITION/TIME CONVERTING MEANS
16
FORWARD/ REVERSE ROTATION JUDGING MEANS
REFERENCE POSITION Θ
REFERENCE SIGNAL
11
DYNAMIC PROPERTIES COMPENSATING ELEMENT
17
20
3
POSITION COMMAND Pc
POSITIONAL DEVIATION ε
+
+
−
1
2
POSITIONAL GAIN
4
VELOCITY CONTROLLER
POSITION FEEDBACK Pf
POSITION DETECTOR
MOTOR
CURRENT AMPLIFIER
CURRENT CONTROLLER
8
7
6
5

FIG. 2

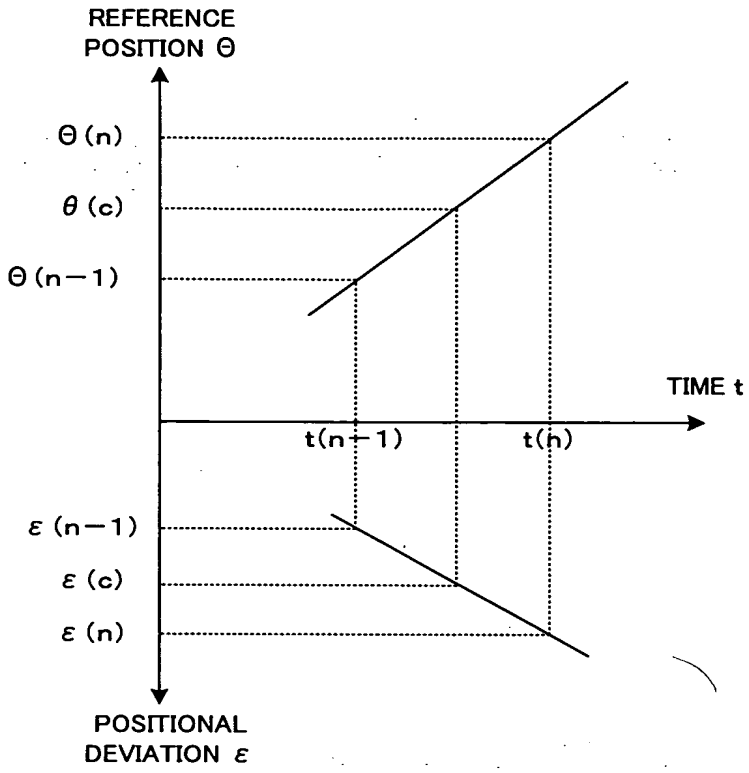

REFERENCE POSITION Θ
Θ (n)
θ (c)
Θ (n−1)
TIME t
t(n−1)
t(n)
ε (n−1)
ε (c)
ε (n)
POSITIONAL DEVIATION ε

FIG. 3

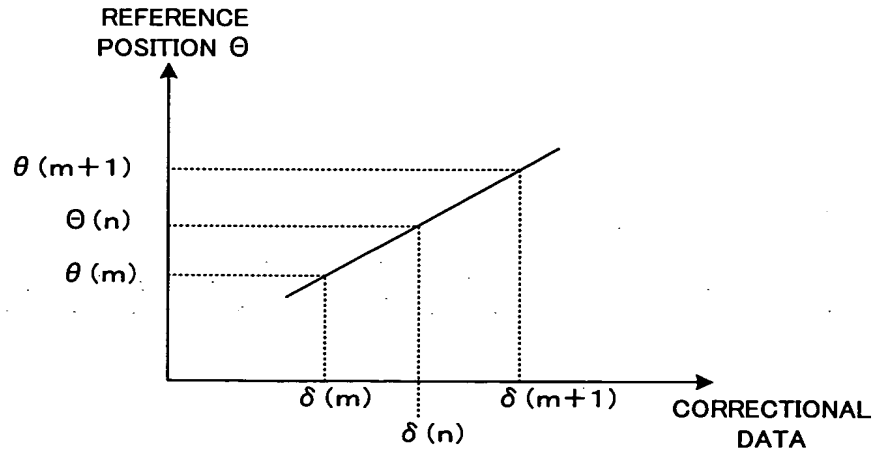

REFERENCE POSITION Θ
θ (m+1)
Θ (n)
θ (m)
δ (m)
δ (n)
δ (m+1)
CORRECTIONAL DATA

FIG. 4

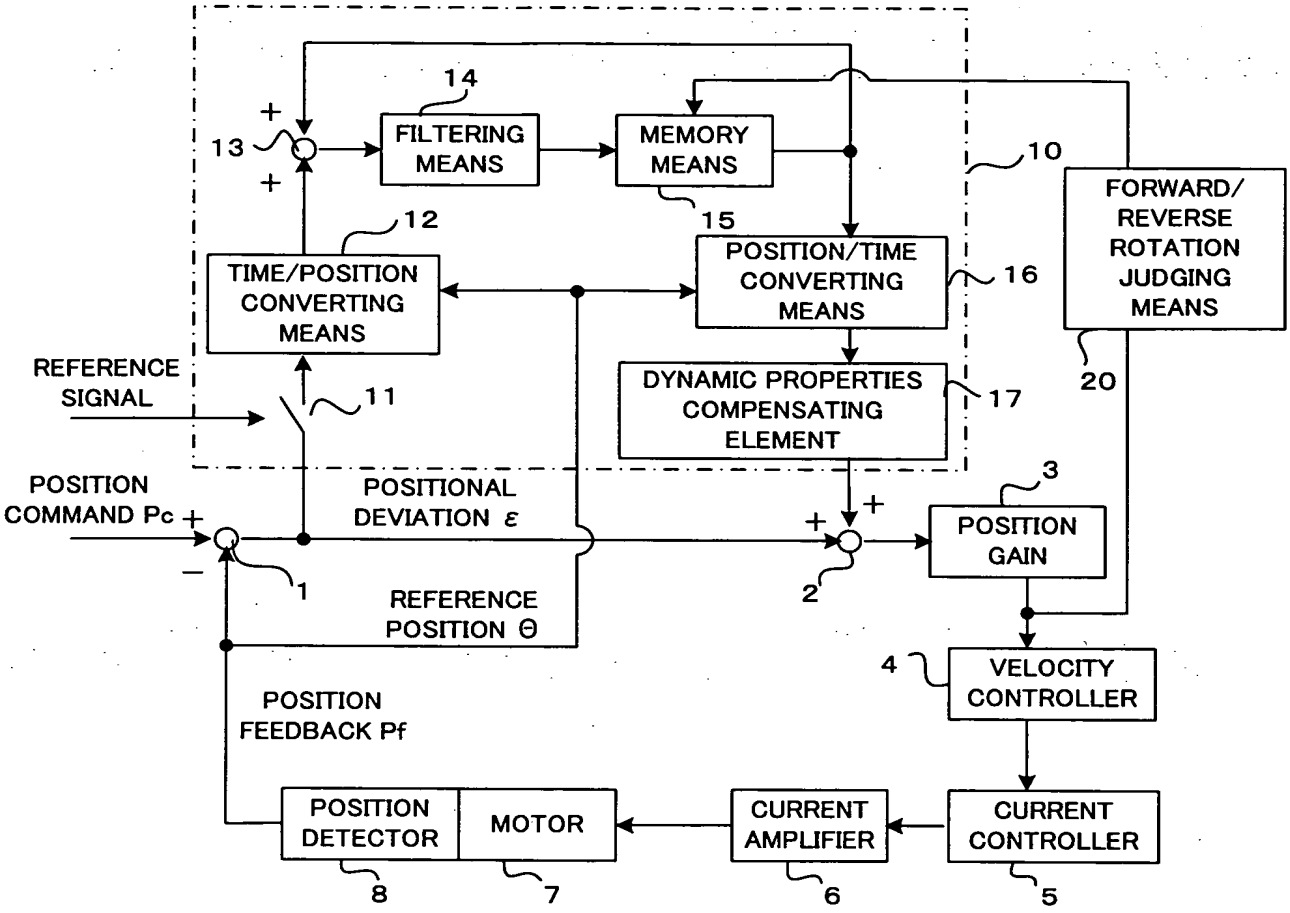

14
FILTERING MEANS
MEMORY MEANS
13
10
FORWARD/ REVERSE ROTATION JUDGING MEANS
15
12
TIME/POSITION CONVERTING MEANS
POSITION/TIME CONVERTING MEANS
16
REFERENCE SIGNAL
11
DYNAMIC PROPERTIES COMPENSATING ELEMENT
17
20
POSITION COMMAND Pc
POSITIONAL DEVIATION ε
3
POSITION GAIN
1
2
REFERENCE POSITION Θ
4
VELOCITY CONTROLLER
POSITION FEEDBACK Pf
POSITION DETECTOR
MOTOR
CURRENT AMPLIFIER
CURRENT CONTROLLER
8
7
6
5

FIG. 5

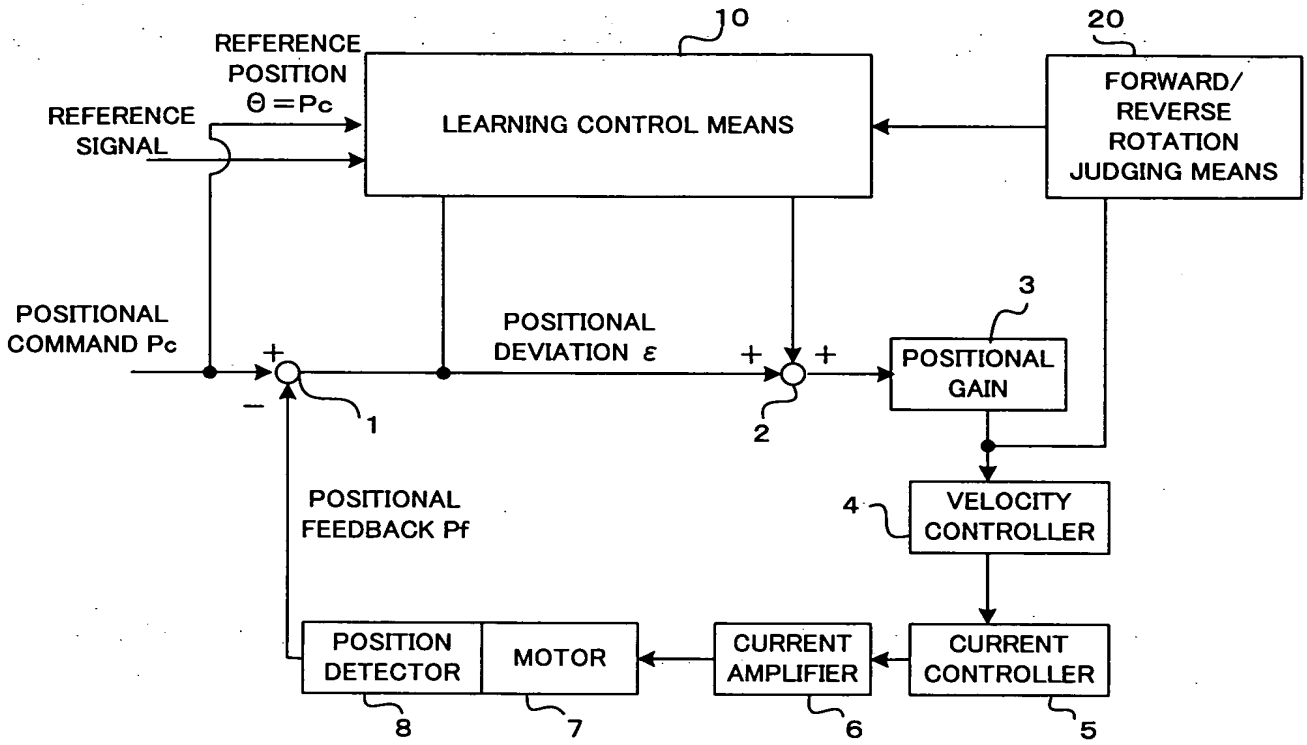

10
20
REFERENCE POSITION Θ=Pc
REFERENCE SIGNAL
LEARNING CONTROL MEANS
FORWARD/ REVERSE ROTATION JUDGING MEANS
POSITIONAL COMMAND Pc
POSITIONAL DEVIATION ε
3
POSITIONAL GAIN
+
−
1
2
POSITIONAL FEEDBACK Pf
4
VELOCITY CONTROLLER
POSITION DETECTOR
MOTOR
CURRENT AMPLIFIER
CURRENT CONTROLLER
8
7
6
5

FIG. 6

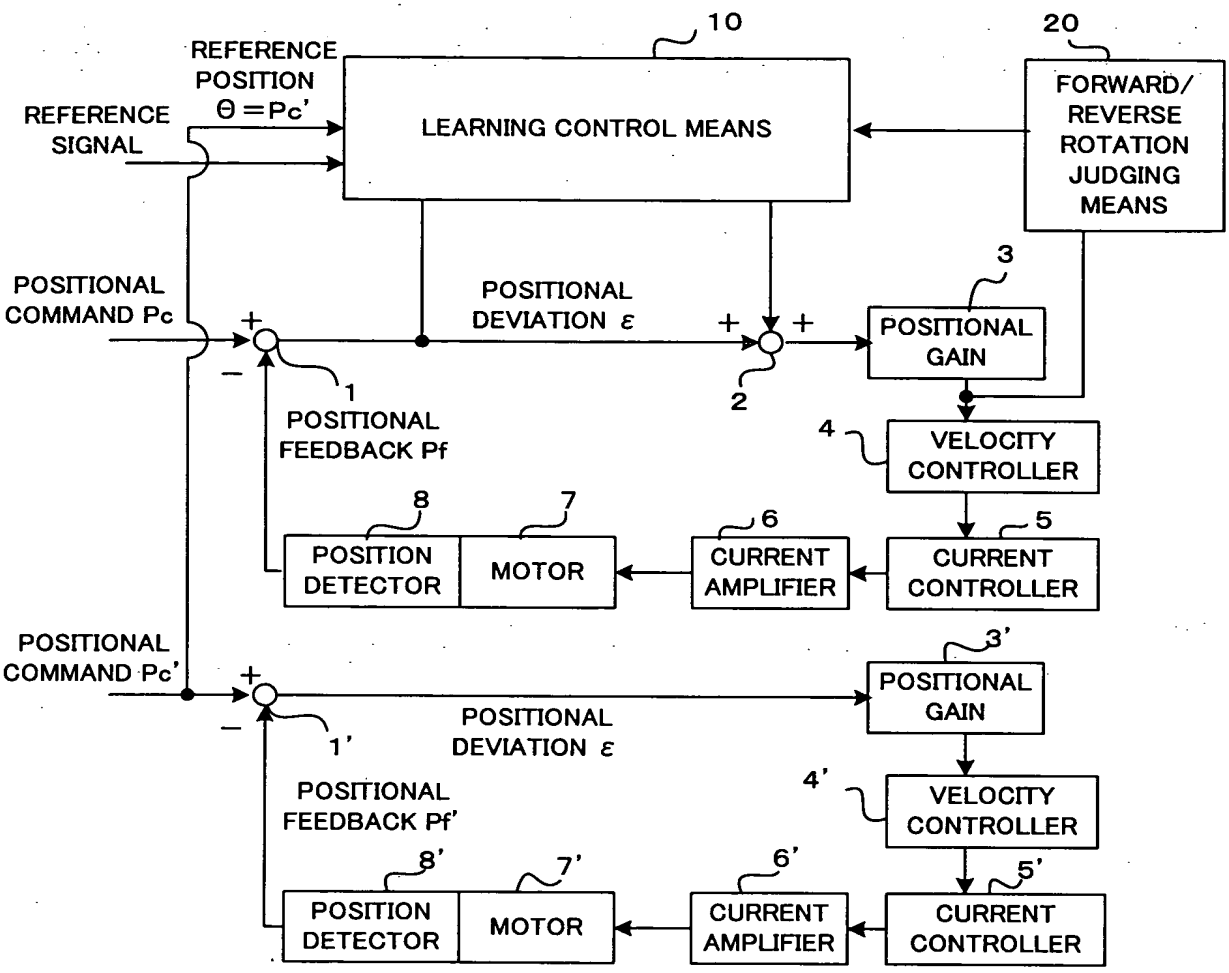

10
20
REFERENCE POSITION Θ=Pc'
REFERENCE SIGNAL
LEARNING CONTROL MEANS
FORWARD/ REVERSE ROTATION JUDGING MEANS
3
POSITIONAL COMMAND Pc
POSITIONAL DEVIATION ε
POSITIONAL GAIN
1
2
POSITIONAL FEEDBACK Pf
4
VELOCITY CONTROLLER
8
7
6
5
POSITION DETECTOR
MOTOR
CURRENT AMPLIFIER
CURRENT CONTROLLER
POSITIONAL COMMAND Pc'
3'
POSITIONAL GAIN
1'
POSITIONAL DEVIATION ε
4'
POSITIONAL FEEDBACK Pf'
VELOCITY CONTROLLER
8'
7'
6'
5'
POSITION DETECTOR
MOTOR
CURRENT AMPLIFIER
CURRENT CONTROLLER

FIG. 7

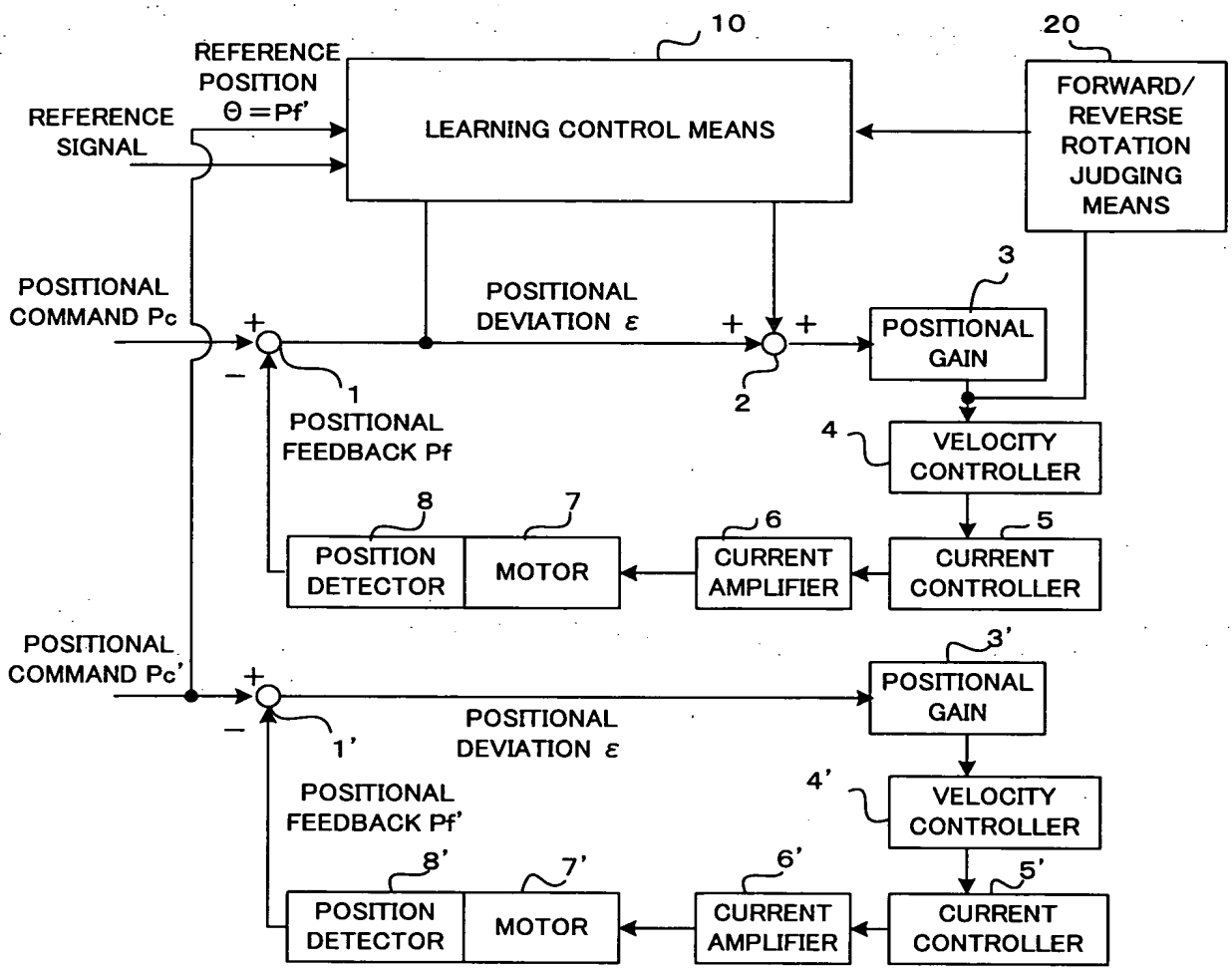

10
20
REFERENCE POSITION Θ=Pf'
REFERENCE SIGNAL
LEARNING CONTROL MEANS
FORWARD/ REVERSE ROTATION JUDGING MEANS
POSITIONAL COMMAND Pc
POSITIONAL DEVIATION ε
3
POSITIONAL GAIN
1
2
POSITIONAL FEEDBACK Pf
4
VELOCITY CONTROLLER
8
7
6
5
POSITION DETECTOR
MOTOR
CURRENT AMPLIFIER
CURRENT CONTROLLER
POSITIONAL COMMAND Pc'
3'
POSITIONAL GAIN
1'
POSITIONAL DEVIATION ε
4'
VELOCITY CONTROLLER
POSITIONAL FEEDBACK Pf'
8'
7'
6'
5'
POSITION DETECTOR
MOTOR
CURRENT AMPLIFIER
CURRENT CONTROLLER

FIG. 8

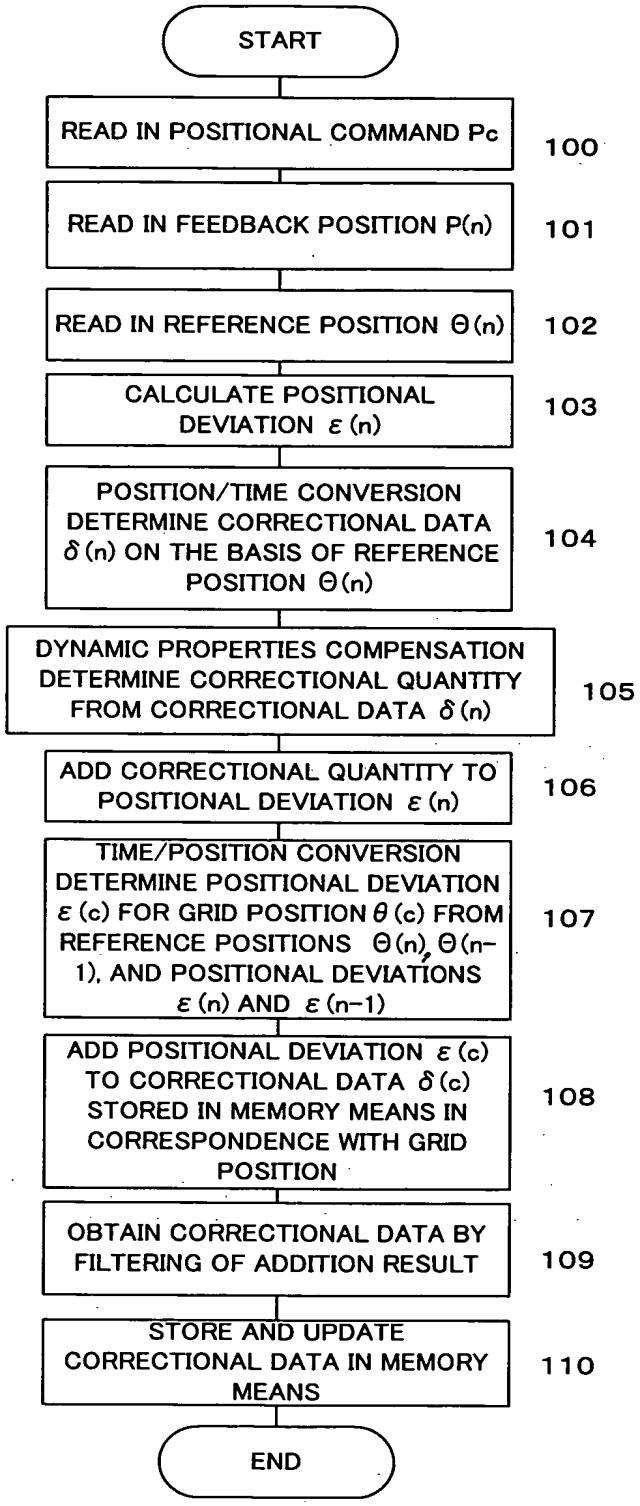

START
READ IN POSITIONAL COMMAND Pc
100
READ IN FEEDBACK POSITION P(n)
101
READ IN REFERENCE POSITION Θ(n)
102
CALCULATE POSITIONAL DEVIATION ε(n)
103
POSITION/TIME CONVERSION DETERMINE CORRECTIONAL DATA δ(n) ON THE BASIS OF REFERENCE POSITION Θ(n)
104
DYNAMIC PROPERTIES COMPENSATION DETERMINE CORRECTIONAL QUANTITY FROM CORRECTIONAL DATA δ(n)
105
ADD CORRECTIONAL QUANTITY TO POSITIONAL DEVIATION ε(n)
106
TIME/POSITION CONVERSION DETERMINE POSITIONAL DEVIATION ε(c) FOR GRID POSITION θ(c) FROM REFERENCE POSITIONS Θ(n), Θ(n-1), AND POSITIONAL DEVIATIONS ε(n) AND ε(n-1)
107
ADD POSITIONAL DEVIATION ε(c) TO CORRECTIONAL DATA δ(c) STORED IN MEMORY MEANS IN CORRESPONDENCE WITH GRID POSITION
108
OBTAIN CORRECTIONAL DATA BY FILTERING OF ADDITION RESULT
109
STORE AND UPDATE CORRECTIONAL DATA IN MEMORY MEANS
110
END

FIG. 9

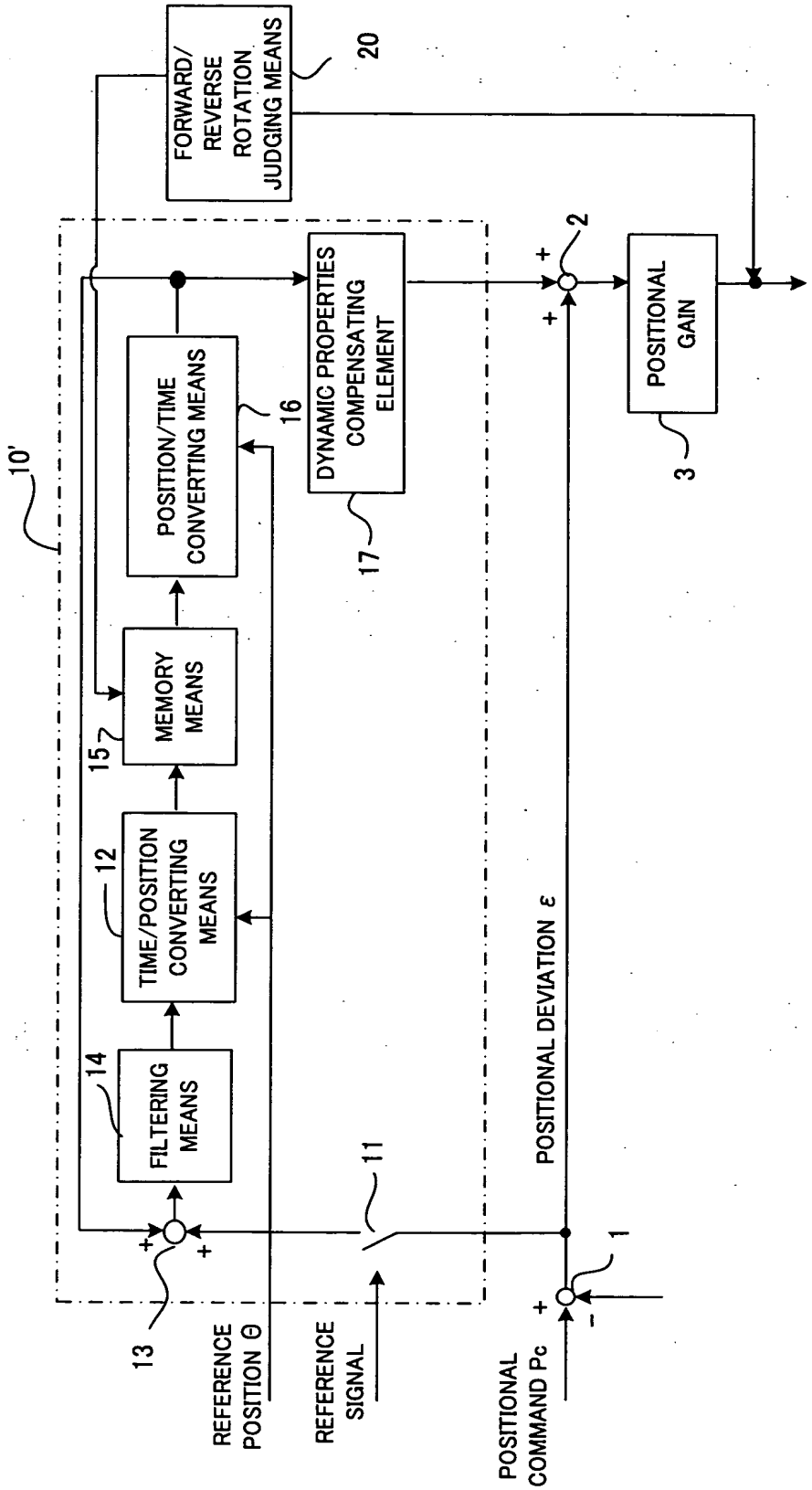
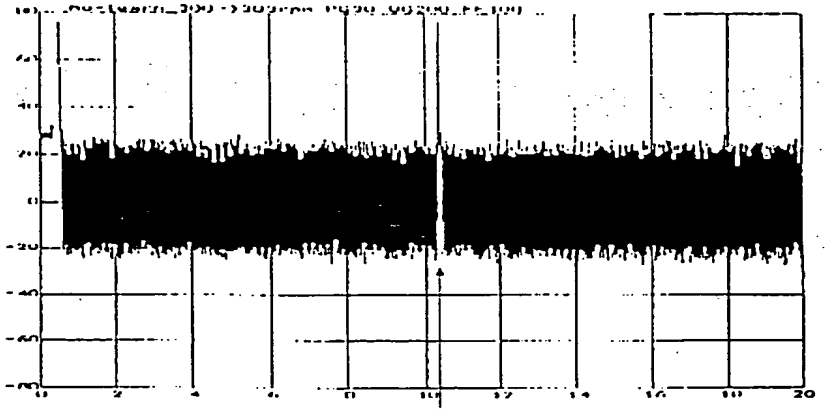
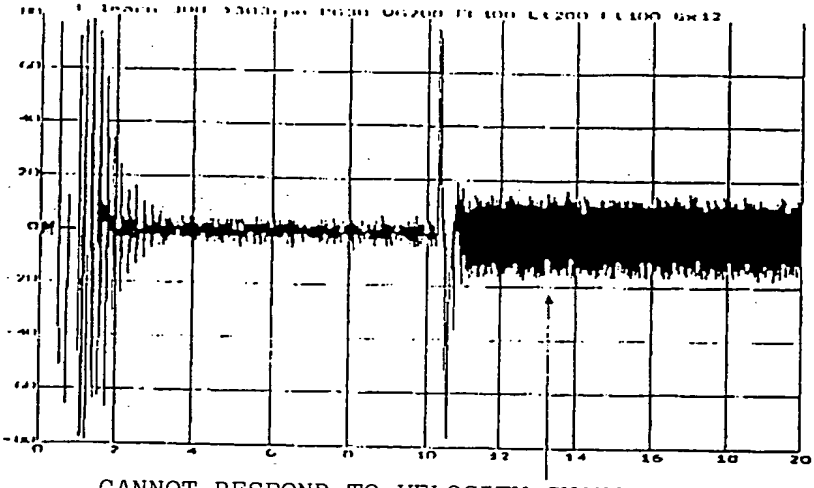

FORWARD/
REVERSE
ROTATION
JUDGING MEANS
20
10'
POSITION/TIME
CONVERTING MEANS
16
DYNAMIC PROPERTIES
COMPENSATING
ELEMENT
17
2
POSITIONAL
GAIN
3
MEMORY
MEANS
15
TIME/POSITION
CONVERTING
MEANS
12
FILTERING
MEANS
14
11
13
REFERENCE
POSITION Θ
REFERENCE
SIGNAL
POSITIONAL DEVIATION ε
POSITIONAL
COMMAND Pc
1

FIG. 10A



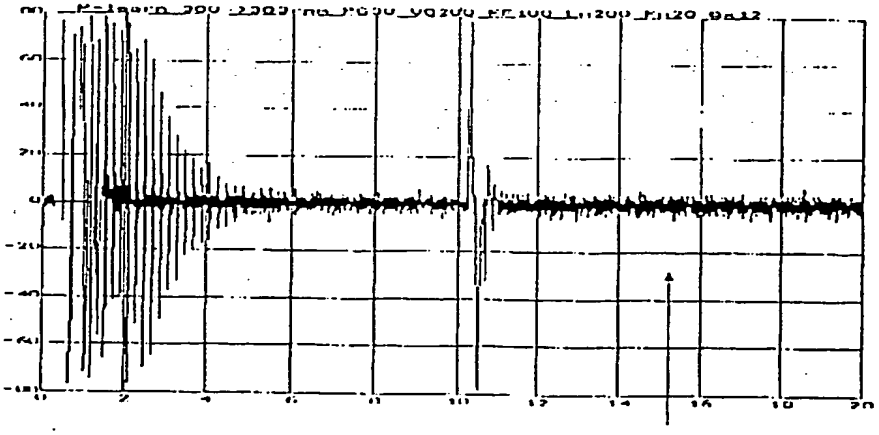
1% VELOCITY CHANGE

FIG. 10B



CANNOT RESPOND TO VELOCITY CHANGE

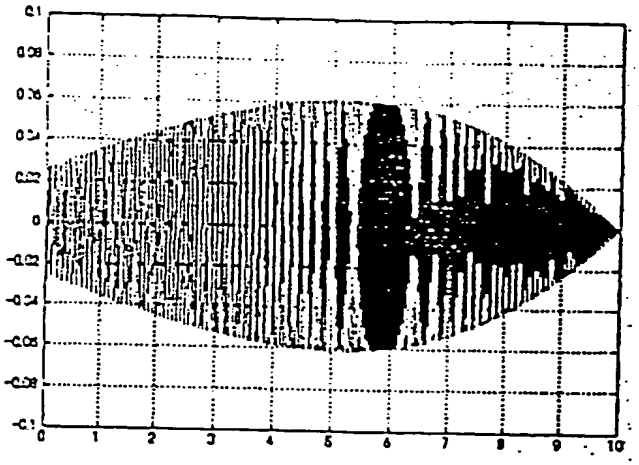
FIG. 10C



CAN FOLLOW VELOCITY CHANGE

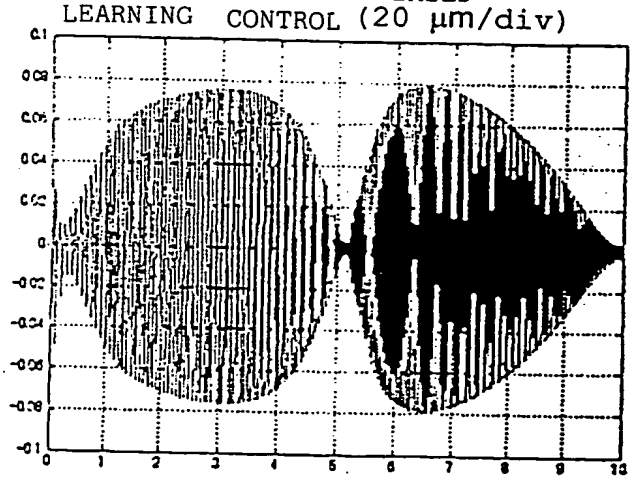
POSITIONAL DEVIATION WHEN LEARNING NOT APPLIED (20 μm/div)

FIG. 11A



CONVENTIONAL TIME-BASED LEARNING CONTROL (20 μm/div)

FIG. 11B



ANGLE-BASED LEARNING CONTROL(1 μm/div)

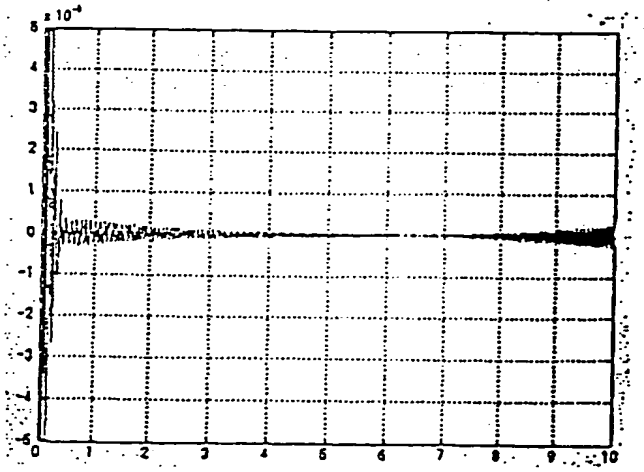



FIG. 11C